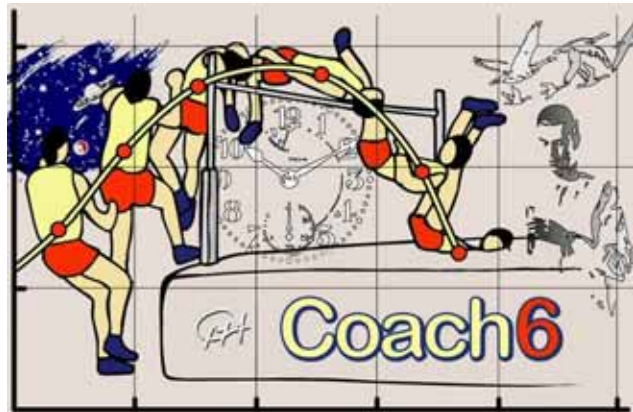


The Basler A602fc High Speed Camera User Guide for Dummies



A project in the discipline by Barbara Neocleous and
supervised by André Heck

1. Introduction:

For the purpose of my Master degree in Mathematics and Science Education I worked on a project with the Basler High Speed Camera. Together with my supervisor, André Heck I captured video clips of various fast natural phenomena. While working on this project we both realized that there are some things that the user of such a camera should have in mind in order for the videos to look nice and to be able to see with the highest quality the underlined phenomenon every time. Many factors can influence the quality of the image and the frame rate. Therefore we decided to write a short and easy guide for the use of this camera in order to help anyone who wants to use it for educational, or any other, purposes. In this guide I will first discuss some important features of the Basler A602fc camera, which is a progressive scan, CMOS, color high speed camera. I continue with a step-by-step description of how to use the camera and the software that is provided with it. At the end of this guide there are some reminders and tricks you can apply in order to get a better quality of the image and ways to achieve high frame rates.

2. The Basler A602fc High Speed Camera

2.1 Conditions for use

It is very important to be careful with this sensitive camera. The housing temperature during operation of the camera must stay between 0°C and 50°C. You are advised to allow sufficient air circulation around the camera to prevent internal heat built-up in your system. Additional cooling devices are not normally required but in case that are necessary, they should be provided in case the spotlights provide additional heat. The relative humidity during operation should stay between 20% and 80%.

2.2 Frame rate

This camera can capture up to 100fps in an 8 bit/pixel output mode and up to 50fps in a 16 bit/pixel output mode at a full resolution of 656 (horizontal) × 490 (vertical). However with a lower resolution and some other adjustments that will be mentioned in the later chapters this camera can capture much more frames per second. In our project we managed to capture up to 600 frames per second.

2.2 Cable length

The cable you will use to connect the camera with your computer should be:

- Maximum 4,5 m for the IEEE 1394 cable
- Maximum 10m for the I/O cables

You should have in mind that the camera comes with a 6-pin firewire cable to connect to a desktop computer. This cable however does not work for laptops because this type of computer usually comes with a 4-pin firewire connector. So in case you want to use the camera with a laptop make sure you buy the specific firewire cable for laptops, which allows the camera to be connected with an external power.

3. How to record a video clip

You can record a video clip with COACH 6 or with video software such as AMCAP, or VirtualDub (1.6 e.v). We will describe in this section how to use the latter software. Use of the high speed camera with in COACH 6 is the same as usage of a standard webcam.

1. Connect the firewire cable to the IEEE 1394 port of the computer



2. Connect the additional free end of the cable to the power supply.

3. Open the AMCAP software on your computer

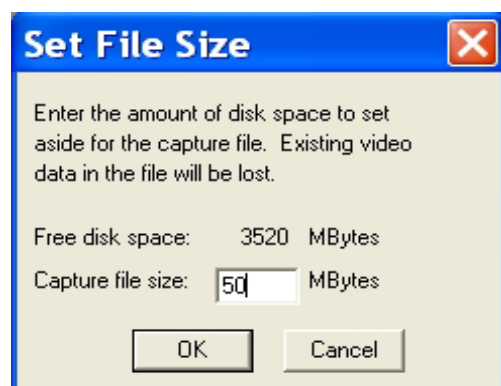
4. Direct the camera towards the object you want to capture and adjust the diaphragm opening by rotating the first ring on the front of the camera (it has the numbers: 16, 8, 4, 2.8, 2, 1.2) so that you have enough light. Adjust the clearness of the image by rotating the second ring.

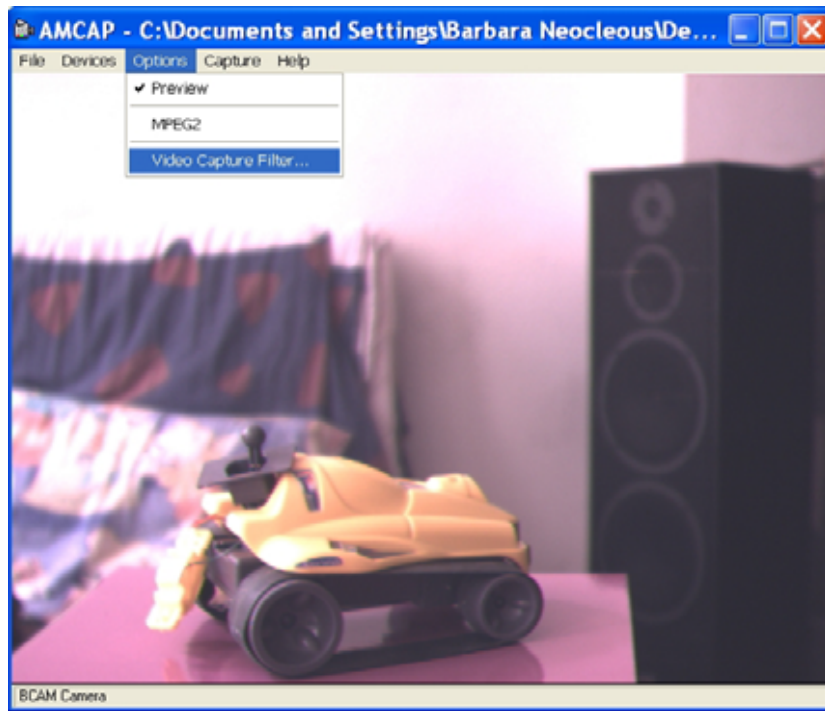


5. Click File → Set Capture File → Give a file name and click enter. Give a capture file size and click enter.

This is the amount of disk space that will be set aside for the capture file. It could help you to know that a 5 minute mp3 song is about 4.5Mbytes.

6. Options → Video Capture Filter → Controls

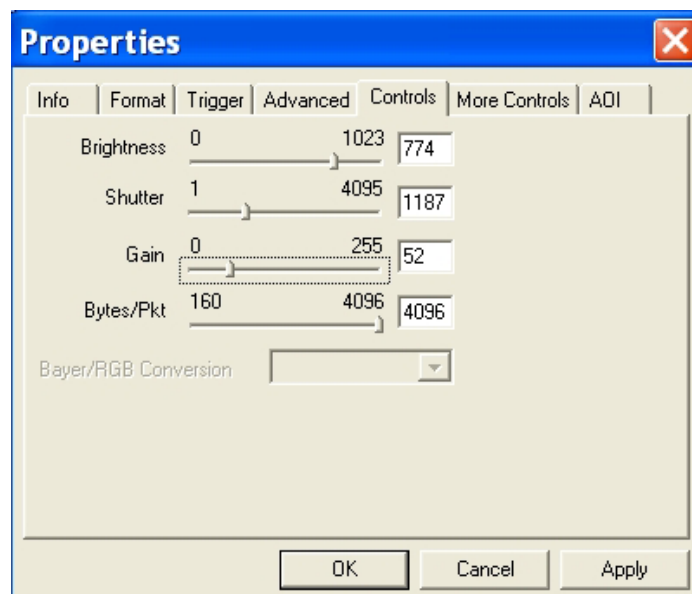




- *Brightness* can be adjusted between 0 and 1023. This will not influence the frame rate but will only help for a better quality image. (see Appendix)
- *Shutter* can be adjusted between 1 and 4095. The value of the shutter influences the frame rate as described by formula (1) and (2). Roughly the maximum exposure time is the reciprocal of the frame rate. Exceeding the maximum exposure time for a given frame rate will casue the camera to slow down. The shutter time base in formula (2) is fixed at 20 μ s (see Appendix). Thus a shutter value setting of 100 would mean a exposure time of $100 \times 20 = 2000\mu\text{s} = 2\text{ms}$.

$$\text{maximum frame rate (in fps)} = \frac{10^6}{\text{maximum exposure time (in } \mu\text{s)} + 128 \mu\text{s}} \quad (1)$$

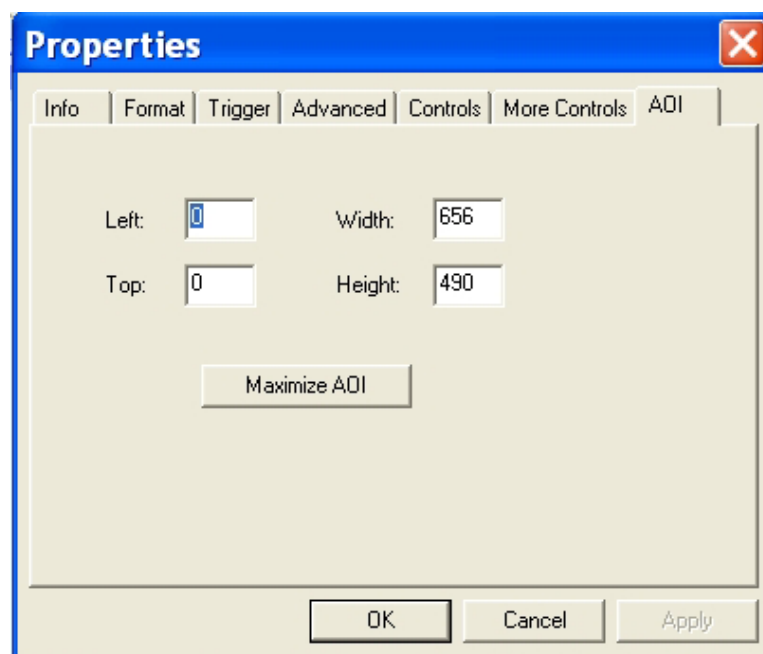
$$\text{maximum exposure time} = (\text{shutter value setting}) \times (\text{shutter time base}) \quad (2)$$



- *Gain* is defined by how much brightness is visible from the screen's centre and can be adjusted from 0 to 255. Changing this parameter will not influence the frame rate of the video (see Appendix), it only adjust the brightness of the clip.
- *Bytes per packet* can be adjusted from 160 to 4096. Changing this parameter has no effect on the image, but the frame rate is influenced. When the bytes per packet are set to the maximum, the camera will transmit frames at its maximum specified rate. When the bytes per packets is reduced, more packets per frame are needed and the camera will transmit the frames at a lower rate according to formula (3) (note: the denominator is the frame transmission time):

$$\text{maximum frame rate (in fps)} = \frac{10^6}{\text{packets per frame} \times 125\mu\text{s}} \quad (3)$$

7. Options → Video Capture Filter → AOI



The area of interest (AOI) feature allows you to specify a portion of the CMOS array to be transmitted out of the camera. You can specify a portion of the array and only that picture information will be transmitted. The rest, which is outside the area of interest, will be discarded. This allows you to record at higher frame rates. This feature is only available when the camera is set to operate in video Format 7, mode 0.

The area of interest is referenced with respect to the top left corner of the CMOS array. As shown in figure 1, the upper left corner is designated as column 0 and row 0. The location and size of the area of interest is defined by specifying its upper left corner point (left column, top row, width and height). The following restriction on the parameter values hold: $\text{Left} + \text{Width} \leq 656$, $\text{Top} + \text{Height} \leq 490$, all values are 0 or divisible by 2.

For example, suppose that you specify the left column as 10, the width as 16 (that means from the 10th column until the 26th) and the top row as 4 and the height as 10 (that means from the 4th row until the 14th). This area of interest in this case is shown in Figure 1.

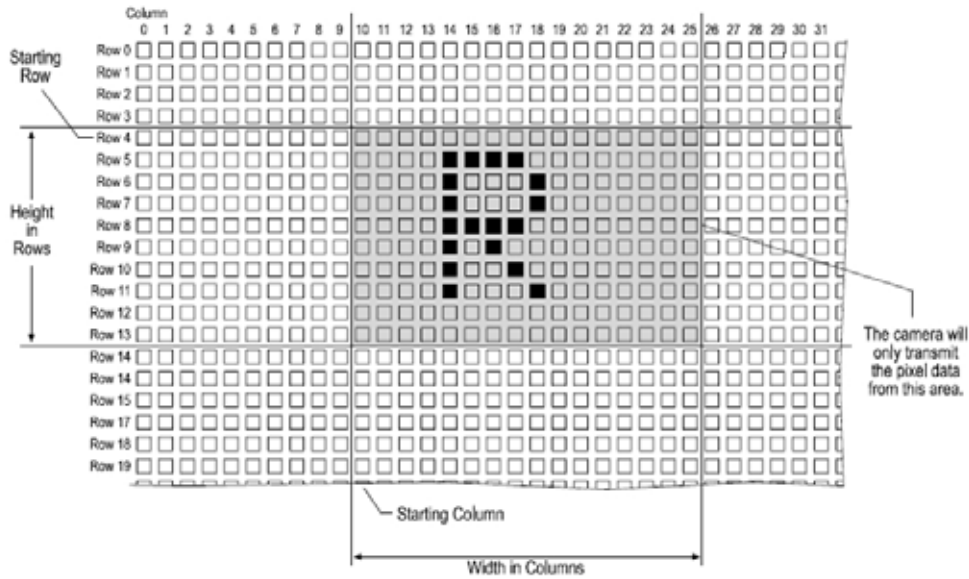


Figure 1

In general, the maximum frame rate for the A602fc camera increases as the size of the AOI decreases because the frame readout time decreases when less information has to be transmitted. Formula (4) shows the exact relationship (the denominator is the frame readout time).

$$\text{maximum frame rate (in fps)} = \frac{10^6}{(\text{AOI Height} + 3) \times 15,28\mu\text{s}} \quad (4)$$

For example, a height of 240 pixels leads to a maximum frame rate 269 fps.

In summary the maximum frame rate depends on the shutter time, the AOI and the bytes per packet. Use your AOI and exposure time settings to calculate a result in each of the three formulas below. The formula that gives the lowest value, will determine the maximum frame rate for the given settings.

Frame rate based on the exposure time

$$\text{maximum frame rate (in fps)} = \frac{10^6}{\text{maximum exposure time (in } \mu\text{s)} + 128 \mu\text{s}} \quad (5)$$

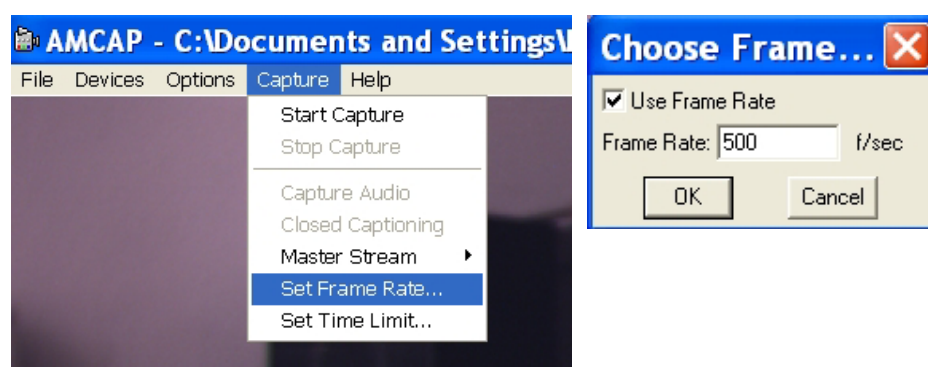
Frame rate based on the frame readout time

$$\text{maximum frame rate (in fps)} = \frac{10^6}{(\text{AOI Height} + 3) \times 15,28\mu\text{s}} \quad (6)$$

Frame rate based on the frame transmission time

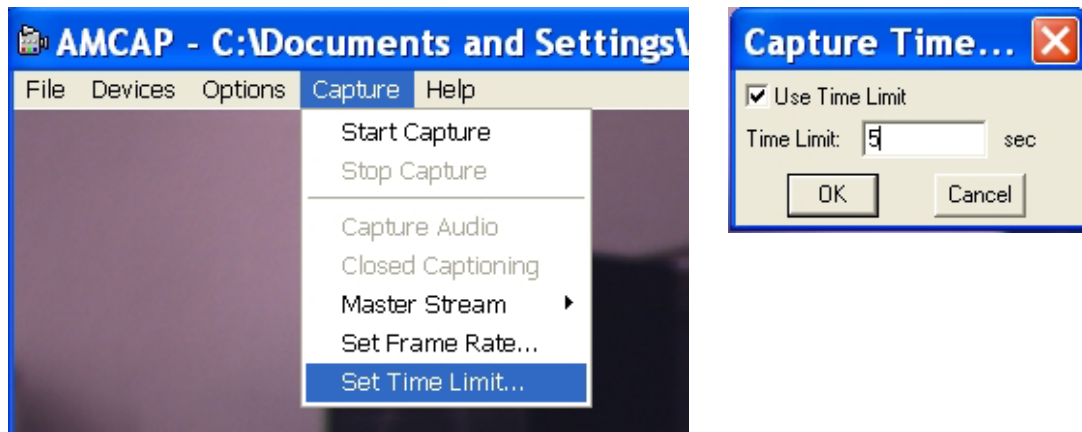
$$\text{maximum frame rate (in fps)} = \frac{10^6}{\text{packets per frame} \times 125\mu\text{s}} \quad (7)$$

8. Capture → Set frame rate



Now you can set the frame rate you want and check the box where it says Use Frame Rate. However in this case you have to make sure that the frame rate you ask for does not exceed the possibilities of the camera with respect to the settings you adjusted. You can use formulas (5), (6) and (7) to make sure that the frame rate you ask for is possible. If not, then the frame rate you will get in practice will not be equal to the frame rate you set.

9. Capture → Set Time Limit



You can type the seconds you want the camera to capture (time limit) and check the box that says Use Time Limit. This will override, if necessary, the file size restrictions set beforehand

10. Capture → Start Capture

When you click this, a notification window will appear asking you to click OK to start capturing. The camera will capture for as long as you set on the Time Limit settings. Otherwise it will keep capturing until you go again to Capture and then Stop Capture. You can also stop the camera from capturing by clicking Esc.



11. Edit the captured video

When you are done with capturing the video, you save it and can then edit it and keep only the frames you need. This can be done with video editing software such as VirtualDub. An outline of using VirtualDub is the following. First you have to import the video and the software will split it out in frames. This way you can see the movie frame by frame and cut out (delete) the frames that you don't need. After doing that you now have the video frames you want and have to save it as an .avi file. However since you do not want to have very big files it is better if you first compress it. This you do by choosing "audio" and make sure that the choice "No audio" is clicked. Then you go to "Video" and you choose "Compression". You choose from the list of CODECS which compression you want. Microsoft MPEG-4 Video Codec V2 is what we used when exporting the video clip for use in Coach 6.

4. Reminders and Tricks of the trade

From our experience we give the following reminders and tricks of the trade.

- Always remember to adjust the diaphragm opening and the focus of the image by rotating the two rings in the front of the camera. Make sure that the image is bright and clear enough for better results.
- As we can see from equation (4), the frame rate is irrelevant to the width of the AOI. That means that in case you want to capture a video with big height and small width (e.g., a bouncing ball) it is better if you rotate the camera 90 degrees to adjust the AOI to a small height and a big width and this will not influence the frame rate.
- For better quality picture make sure you have enough light towards your area of interest. This way the exposure time can be set to low values and you can obtain higher frame rates. If the image is too bright then you can adjust the brightness from the settings, and this will not influence the frame rate.

5. Video Drivers and Video Formats

Until we have always assumed that the Basler BCAM 1394 video driver is used in combination with AMCAP capturing software and that the camera operates in the video format 7, mode 0. In video format 7, the frame rate is determined by the setting in the Bytes per Packets field. This means that you can change the frame rate by adjusting parameters such as exposure time, area of interest, and so on. Alternatively, you can use the video format 0, in which the frame rate is determined by the Frame Rate field. Frame rate ranges then from 1.875 up to 60 depending on the output format. Format 0, mode 1 is used to capture in color with resolution of 320×240 ; Format 0, mode 3 is used to capture in color with resolution of 640×480 ; Format 0, mode 5 is used to capture in gray scale with resolution of 640×480 .

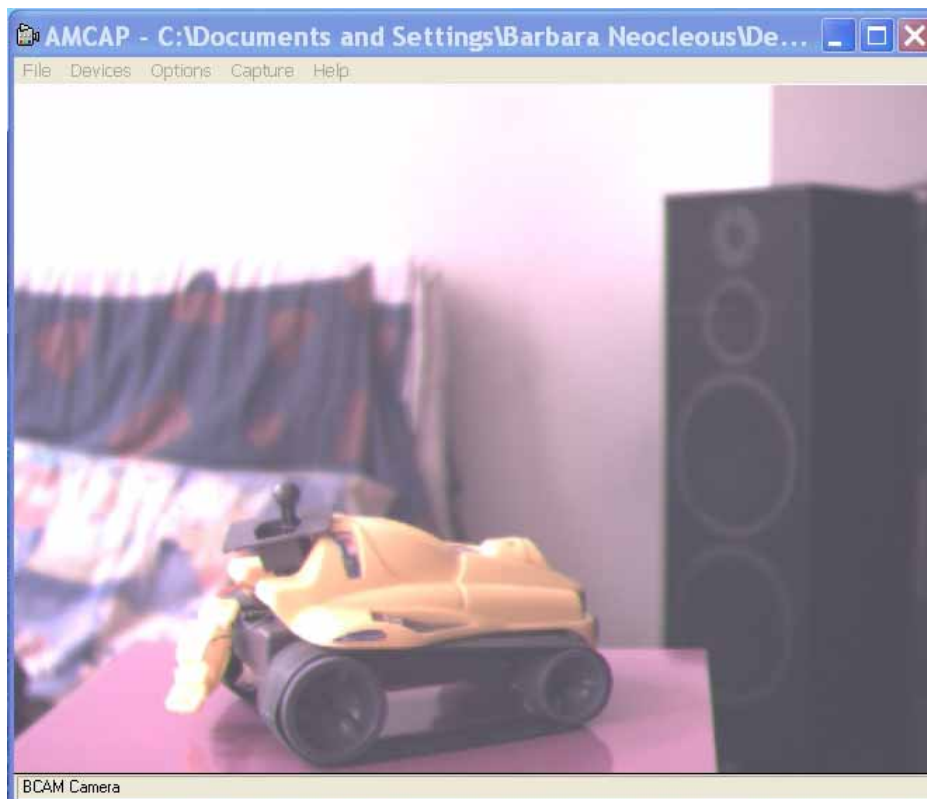
In Spring 2007, a new driver became available for the Basler cameras using the GenICam standard (www.genicam.org) and the pylon driver V1.0 became available. The pylon driver offers reliable image data transport into the memory of your PC at a very low CPU load and it contains a DirectX interface. The pylon viewer is a standalone application to view and change parameter settings of the camera. It works well together with the capturing programs like AMCAP and VirtualDub. In the latter case, the frame rate cannot be preset, but capturing will take place at maximum frame rate.

APPENDIX

1. How does the image changes with the brightness.

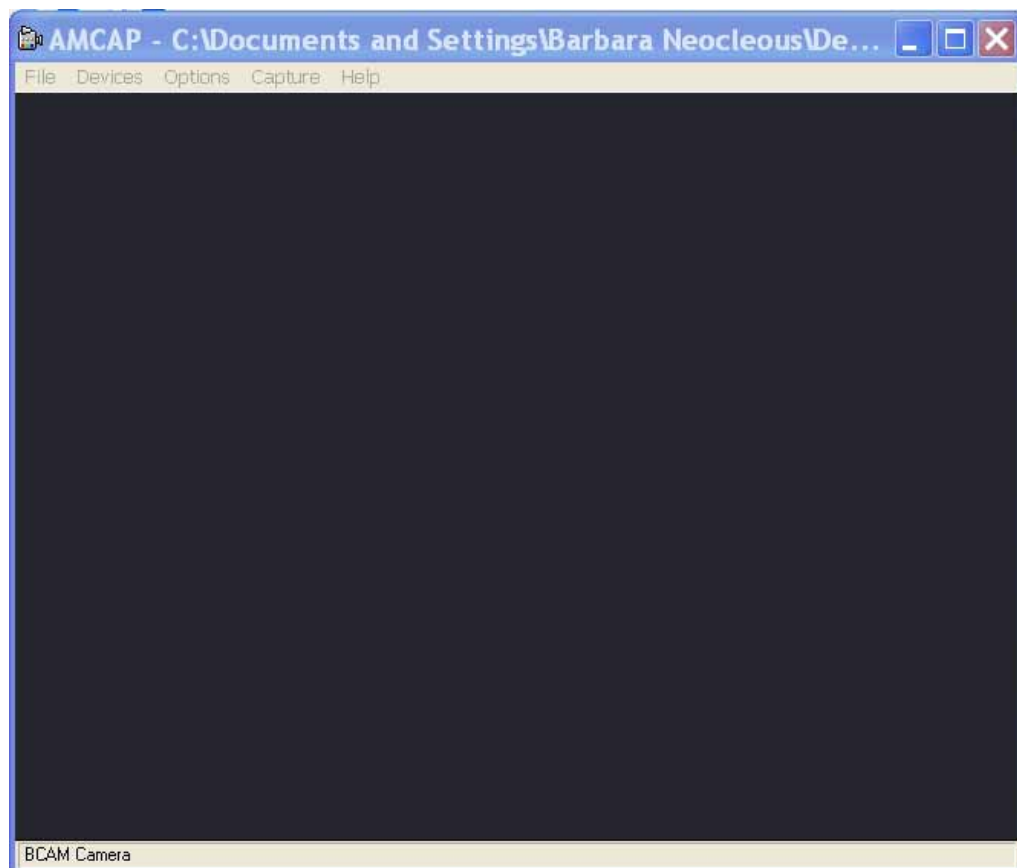


Picture 1: Brightness is set to 0 (minimum)



Picture 2: Brightness is set to 1023 (maximum)

2. How does the image changes with the shutter



Picture 3: Shutter is set to 1 (minimum)



Picture 4: Shutter is set to 4095 (maximum)

3. How does the image changes with the gain



Picture 5: Gain is set to 0 (minimum)



Picture 6: Gain is set to 255 (maximum)